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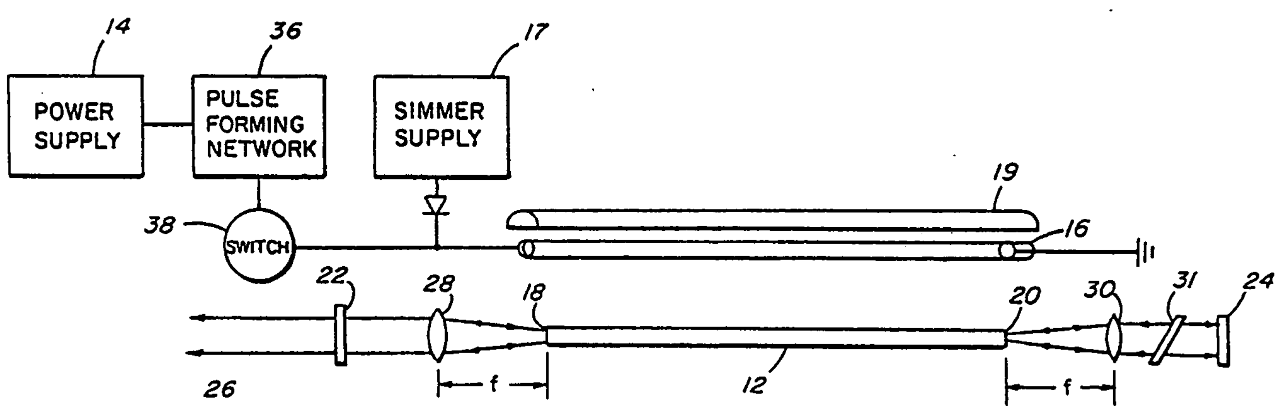
(54) Title: LONG PULSE TUNABLE DYE LASER



(57) Abstract

A tunable dye laser has been found particularly suited to selective photothermolysis. A longer pulse duration which makes the system suitable for a wider range of applications is obtained by modifying the laser to generate a spatially noncoherent beam. The optical system at each end of the laser cell (12), which may include a lens (28, 30) or spherical mirror (32, 34), refocuses the aperture (18, 20) of the dye cell near to itself so that substantially all light emanating from the dye cell is returned to the dye cell until the light passes through one of the optic systems as a noncoherent laser beam. A tunable intracavity element (31) tunes the laser across the gain curve of the dye solution. The pulse duration of the laser beam can be selected from a range of durations up to about one millisecond.

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LONG PULSE TUNABLE DYE LASER

Description

Field of the Invention

This invention relates to lasers and in particular to laser systems suitable for medical applications such as selective photothermolysis.

Background

The use of lasers in selective photothermolysis has been reported by Greenwald et al., "Comparative Hystological Studies of the Tunable Dye (at 577 nm) Laser and Argon Laser: The Specific Vascular Effects of the Dye Laser", The Journal of Investigative Dermatology 77:305-310, 1981, and by Anderson and Parrish, "Selective Photothermolysis: Precise Microsurgery by Selective Absorption of Pulse Radiation", Science 220:524-527, 1983. In this technique, targeted tissues are heated by laser light, the wave length of which is selected to be specifically absorbed by the targeted tissues. The laser pulse duration is tailored to the size of the target. Tissues surrounding the targeted structures are spared.

The above studies highlight the need for selecting lasers which meet both the spectral requirements of a given application and pulse duration requirements. It is important that the laser be tunable to select the color of the source

to match some spectral property of the targeted tissue. The special spectral features of targets require specific wavelengths, but only require moderate linewidths (1-4 nm) to induce selective effects. Proper laser pulse duration is important to heat target tissue to denature the tissues without boiling or vaporization. The temperature limits are tight, from body temperature of 35 C to a temperature well below boiling point, about 70 C. Ordinary calorimetry states that temperature rise is proportional to energy and inversely proportional to target volume irrespective of the time it takes to deliver the energy. If thermal diffusivity is added there is a pulse duration criterion and the energy must be deposited quickly to minimize heat dissipation to surrounding tissue. However, selective photothermolysis heat must not be deposited too quickly so as to exceed the boiling point in the targeted zone.

The situation gets more complex if small absorbing chromophores such as hemoglobin in blood cells are used as absorbers to treat blood vessels which are an order of magnitude larger. The radiation must be added at low intensities so as not to vaporize the small cells, left on long enough to heat the blood vessels by thermal diffusion to the point of denaturation and then turned off before the surrounding tissue is damaged.

Some control in intensity is available by the adjustment of the spot size of the pulsed radiation

source. A source capable of delivering more than a joule is necessary so that spot sizes do not become too tiny with a concomittant increase in treatment time.

The above studies have shown the dye laser to be particularly suited to selective photothermolysis. Dye lasers are readily tunable to selected wave lengths by means of the choice of dye, wavelength selective filters in the cavity and the like. Further, dye lasers can provide high output energies and short pulse durations. Unfortunately, the typical dye laser pulse duration of only a few microseconds or less is too short for many applications using selective photothermolysis. Dye lasers with nanosecond or shorter pulses are preferred for subcellular organelle targeting and microsecond or shorter pulses are preferred for cell targeting. However, dye lasers do not typically provide the millisecond pulses which are best for blood vessels and other small structures.

It is generally recognized that the quenching of a dye laser after microseconds may be due to the accumulation of dye molecules in the triplet state by means of intersystem crossing from the singlet state. Laser action in a dye laser starts from the singlet states. Molecules which cross over to the triplet state often absorb at the laser wavelength and inhibit laser action. The triplet state effect has been investigated and triplet state quenchers have been reported for specific dyes. However,

triplet quenchers for all dyes used in lasers have not been identified. But, even with the use of triplet quenchers, pulse durations of several hundred microseconds have only been obtained at low energy outputs of not more than a few tenths of a joule.

A second problem that makes it difficult to generate long pulses in a dye laser is the distortion of the liquid amplifying medium by absorbed, conducted and convected heat from the laser excitation source. Such distortions are unavoidable but must be minimized for laser action to continue for milliseconds.

Disclosure of the Invention

A laser has been developed which is more suitable for selective photothermolysis because the laser pulse duration is adjustable to durations approaching one millisecond. The present laser is based on the recognition that thermal distortion in the laser medium results in changes in the index of refraction in the medium and loss of resonating modes for which the laser is designed.

In accordance with principles of the invention, a multiple pass light amplifier, which may be considered a spatially noncoherent laser, comprises a cell having a medium excitable to an energy level with net optical gain and having apertures at opposite ends of the cell. The Fresnel number of the cell is greater than one, distinguishing it from

wave guide lasers. Means such as a flashlamp is provided for raising the medium to an inverted energy configuration. An optical system at each end of the cell images each aperture upon itself. As a result, substantially all light emanating from the aperture, within a wavelength band determined by the dye solution and any tuning element, is returned to the cell through the aperture. The optical system at one end of the cell allows part of the light to escape and be used.

The resultant beam of light which passes through one of the optical systems has directional concentration to a solid angle substantially less than one steradian, in the order of 10^{-4} steradian, although that concentration is somewhat less than the solid angle of 10^{-8} steradian of conventional lasers. A pulse length greater than 100 microseconds, even approaching one millisecond, is possible even with output powers of over one tenth joule. In fact, a pulse duration of 500 microseconds has been obtained with output powers in the order of joules.

In one form of the embodiment, the means for imaging the aperture on itself is a spherical mirror located a distance from the aperture about equal to its radius of curvature. In another embodiment, a lens is positioned between the aperture and the flat mirror. The lens is positioned at about its focal length from the aperture. The light emanating from the cell is collected by the optical system and

reflected back into the cell. The light traverses the cell in a number of total internal reflections off other cell walls. The dye solution in an excited state amplifies the light rays traversing the cell. The gain medium has a continually changing index of refraction, light rays traversing the cell have no fixed pattern and resonator modes are not established; rather, the spontaneous emission localized in a cone determined by the reimaging optics is amplified on successive round trips through the cell throughout the duration of the laser pulse.

In a system designed specifically for selective photothermolysis, the power supplied to the flashlamp is provided with a variable pulse length circuit which provides for variable length pulses in the range of at least about 10 to 500 microseconds. Preferably, the system allows for pulses of up to one millisecond duration. An output of at least about one joule is provided.

Description of the Drawings

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily

to scale, emphasis instead being placed on illustrating the principles of the invention.

Fig. 1 is an illustration of a preferred embodiment of the invention.

Fig. 2 is an illustration of an alternative embodiment of the invention using spherical mirrors.

Fig. 3 graphically illustrates a typical laser pulse plotted over the flashlamp excitation pulse and showing thermal distortion in the laser pulse.

Fig. 4 is a graphical illustration of a laser pulse over the flashlamp excitation pulse in a system embodying the present invention.

Fig. 5 is yet another embodiment of the invention having a bent gain medium.

Description of Preferred Embodiments

The earliest work in generating long pulses with dye laser concentrated on reducing triplet absorption effects. Dissolved oxygen and other chemicals considered to be triplet quenchers were added to the dye solution to deactivate any triplet states generated by long excitation pulses. Our present studies show that the additives or triplet quenchers do help to increase pulse duration. However, the additives may also help increase pulse duration because they lower laser threshold levels rather than minimize triplet absorption.

The early termination of laser action during a long excitation pulse is considered to be primarily of thermal origin. Heat is absorbed by

the solution and heat is convected from the lamp to the dye cell if the pulse is long enough. Acoustic velocities are in the order of 0.5 mm/microsecond, and with a dye cell bore of 4 or 5 mm there will be density and index of refraction gradients throughout the cell when laser pulses are longer than ten microseconds. If the gradients are very large, the result is a loss of identifiable resonating modes and quenching of the laser output.

A laser system embodying the present invention is shown in Fig. 1. The system is a modification of a conventional flashlamp excited dye laser. In such lasers, a laser medium in the form of a dye carried by a liquid is directed through the dye cell from one end to the other. Through external temperature control equipment, the medium is maintained at a uniform and constant temperature. To excite the laser medium, a high voltage developed in a power supply 14 is applied across a flashlamp 16. As in conventional flashlamp excited dye lasers, a small simmering current may be applied from a supply 17 to the flashlamp prior to starting a pulse from the supply 14 in order to develop a significant level of ionization in the flashlamp prior to discharge.

Light energy from the flashlamp is directed inward to the laser medium by means of a reflector 19. The energy from the flashlamp is absorbed by the laser medium and moves molecules in the medium from the ground state to excited singlet states. As in conventional lasers, as those molecules return to

their ground state they emit photons of a particular wavelength. Part of the light emanates from apertures 18 and 20 at each end of the dye cell. The light is returned through the apertures into the cell by respective mirrors 22 and 24. The returned photons react with molecules of the laser medium in the excited singlet state to cause those molecules to return to the ground state and themselves emit photons of the particular frequency. The thus emitted photons are in phase with the photons striking the molecules and are directed in the same direction as the original photons.

In a conventional laser, the optics at each end of the dye cell 12 are designed such that the photons travelling back and forth between the two mirrors 22 and 24 follow specific paths such that the photons resonate in particular modes. The photons resonate at a common frequency and phase. Finally, the light between the mirrors reaches an intensity such that a measurable amount passes through the mirror 22, which is not a full reflector, as a beam 26. In a conventional laser, the beam 26 is coherent and the divergence of that beam is very small, in the order of 10^{-8} steradians. To provide the resonating modes of a conventional laser, the laser optics must be precisely designed. Thermal distortions in the laser medium result in gradients in the index of refraction of the medium

which in turn destroy the precise optic specifications of the system. The result is a loss of resonating modes and quenching of the laser output.

In the system of Fig. 1, lenses 28 and 30 are provided between respective apertures 18, 20 and mirrors 22, 24. In accordance with the present invention, the optics at each end of the dye cell are designed to return substantially all of the light emanating from the apertures 18 and 20 back into the dye cell rather than to return just the spatially coherent light which travels substantially coaxially in the system. There is no attempt to establish resonating and coherent modes in the present system.

The lenses 28 and 30 are positioned at about their focal lengths f from the apertures 18 and 20. As a result, each aperture is reimaged onto itself through the lenses and flat mirrors. By thus selecting and positioning the lenses, substantially all of the light emanating from the apertures, independent of resonating modes, is returned to the dye cell.

The optics mix the resonating rays and thoroughly homogenize the beams. Any thermal distortions which are induced by the flashlamp are of little consequence because there are no resonator modes. The rays traverse the cell and are amplified but do not follow a precise path determined by the optics. Those rays that are highly deviated as to miss the dye cell are lost. The homogenization is

random and there is no phase relation at the wave front. The modes if any are randomly oriented and completely homogenized. The randomness is spatial as well as temporal. Spatial coherence is not preserved but monochromaticity can be partially preserved with suitable wavelength selective elements. The medium has gain and a definite threshold and therefore is classified a laser.

As in conventional lasers, a tuning element 31 may be provided to tune the laser output within the gain curve of the dye solution. The tuning element can reduce the bandwidth of the beam to less than .01 nanometers and is used to match the absorption band of the target to enhance the desired physiological effects. The most effective tuning elements are those that do not depend on this spatial coherence. The tuning element may be an etalon, a birefringent filter or a prism.

Fig. 2 illustrates an alternative embodiment of the invention in which the optics at each end of the dye cell are replaced with spherical mirrors 32 and 34. Each mirror is positioned at a distance from the aperture 18, 20 which about equals its radius of curvature R. Each spherical mirror reimages the aperture back on itself as do the optical systems in the prior embodiment.

The systems of Figs. 1 and 2 do not provide the coherent radiation of a conventional laser, and their output beams diverge across a solid angle of 10^{-4} steradians. However, in an application such as

selective photothermolysis, the large depth of field obtained from coherent radiation is not required. The concentration of light, though not as great as with the conventional laser, is significantly greater than the one steradian obtainable with nonlaser radiation and is adequate for selective photothermolysis. The advantage of the present system, as applied to selective photothermolysis, is that the beam is not limited by thermal distortion to a pulse duration of less than ten microseconds. Rather, pulse durations approaching one millisecond are possible.

There is a relation between laser pulse duration and the aspect ratio l/d where l is the cell length and d is the bore. A 12" gain length with a 4 mm bore cell lases for 125 microseconds before beam break up occurs. An 18" gain length laser with a 4 mm bore using the same set of optics lases for over 400 microseconds. The larger aspect ratio a/l where a is the radius of the dye cell bore and l the length of the cell, the longer are the pulses. The pumping intensities are kept constant by controlling the current density through the flashlamp. Energy levels up to five joules have been measured.

With the longer pulse durations available with the present system, the dye cell is now suited to a wider range of applications. Further, the pulse duration can be made variable to meet a number of different applications. To that end, a pulse forming network 36 is provided to generate electrical

pulses and transmit the pulses to the flashlamp 16, through a relay switch 38. The pulse width may be selected from the range of 10 microseconds to 500 microseconds and preferably to as high as one millisecond.

Standard plane-plane or confocal laser resonators show thermal effects at times in the order of ten microseconds. The symptom for thermal distortion is an instability in the amplitude of the laser output pulse. In general, flashlamp excitation pulses have a smooth envelope and the laser output pulse closely follows the excitation pulse. If thermal effects distort the laser medium, then the laser intensity will show an amplitude fluctuation. Figure 3 shows the output of a laser with a standard laser configuration; the laser pulse shows amplitude fluctuations after ten microseconds. Such amplitude fluctuations are seen in all long pulse dye lasers that use standard laser resonators. Figure 4 shows the same laser with a laser resonator configuration according to this invention that compensates for the thermal effects; the amplitude fluctuations are eliminated.

This system is similar to a waveguide resonator in that the sum of the focal lengths is less than 1, the optical length between the mirrors. However, it is not a waveguide resonator for the following reasons. (1) There is no restriction on the Fresnel number of the guide. The Fresnel number is equal to $a^2/ 1$ where a is the radius of the dye cell, is the

wavelength, and l is the length of the cell. The waveguide resonator works with guides that have a Fresnel number less than one. Typical Fresnel number for the long pulse dye laser is 6 to 10 or even larger. For example, for a typical system a equals 2 mm, l equals 0.5 to 0.5 meters and equals .5 micrometers. (2) The waveguide laser has resonator optics that match the free space TEM_{00} mode to some of the lower order waveguide modes such as the HE_{01} or HE_{11} mode. There is no such restriction in the present system. There is no unique curvature for the mirrors to go with the aperture of the waveguide as in the true waveguide laser. (3) Resonating modes are absent in the present sytem, and any ray that is reimaged on the exit/entrance aperture can have net gain. The beam divergence is large but still less than that emanating from a guide with a given numerical aperture, or from a tube whose optical beam divergence is defined by the aspect ratio of the tube. Because of the large beam divergence, tuning elements that depend on minimum beam divergence are not effective as line narrowing elements. However, etalons are effective and linewidths to .03 Angstroms have been obtained using the present system. Birefringent filters have also been used to tune the present system.

The present laser advantageously satisfies the criteria for selective photothermolysis. A dye laser emitting at 575 nm with pulse durations up to

400 microseconds has been developed for the treatment of cutaneous vascular lesions such as birthmarks. Such birthmarks are caused by a high density of blood vessels close to the surface of the skin. These blood vessels can be eliminated by selective photothermolysis. The selective photothermolysis laser should emit at 575 nm where blood has secondary absorption maxima at least an order of magnitude larger than that of pigmented tissue of fair skin. The laser should emit pulses about one millisecond long to couple energy into the blood vessels which are several hundred microns in diameter. The vessel will then be heated to denaturation temperature without vaporizing the blood cells. The laser should then be turned off before tissue surrounding the blood vessels is damaged.

A laser with variable pulse duration can be used in selective photothermolysis for a number of medical treatments other than the treatment of cutaneous vascular lesions. These include hemostasis of bleeding ulcers, suppression of choroidal neovascularization that leads to blindness, and hemostasis after the removal of eschar in burn therapy. If exogenous chromophores can be selectively injected into target tissue, the principle of selective photothermolysis treatment with tunable, variable pulse duration lasers can be extended to cover many medical applications too numerous to mention.

Fig. 5 illustrates a modification of the system of Fig. 1 which is possible with the present system.

Because the primary parameter of importance is the relation between the focal length of the optical system and the distance to the dye cell aperture and not the length of the dye cell itself, a bend as shown in the dye cell 36 of Fig. 5 is possible. With a conventional laser, that bend would provide different path lengths through the medium which would destroy the resonating modes of the system.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

CLAIMS

1. A multiple pass light amplifier comprising:

   a cell having a medium excitable to an energy level with net optical gain and apertures at opposite ends thereof, the Fresnel number of the cell and optics being greater than one;

   means for raising the energy level of the medium to have net optical gain; and

   an optical system at each end of the cell for imaging each aperture near to itself.

2. A multiple pass light amplifier as claimed in Claim 1 wherein each optical system comprises a spherical mirror positioned at a distance from the aperture about equal to its radius of curvature.

3. A multiple pass light amplifier as claimed in Claim 1 wherein at least one of the optical systems comprises a flat mirror and a lens positioned between the mirror and the aperture at about the focal length of the lens from the aperture.

4. A method of amplifying light to develop a pulsed beam of light at least 100 microseconds in duration and at least one tenth joule comprising:

for at least 100 microseconds, energizing a medium in a cell to an energy level in which the medium has net optical gain; and

from each end of the cell collecting substantially all light within a wavelength band emanating from the cell and returning the light into the cell such that the cell amplifies the light to form a spatially noncoherent beam of light of directional concentration to a solid angle substantially less than one steradian.

5. A method as claimed in Claim 4 wherein the spatially noncoherent beam of light has a directional concentration to a solid angle of about 10^{-4} steradian or less.

6. A method as claimed in Claim 4 wherein the bandwidth of the amplified beam is reduced by means of a tuning element.

7. A system for generating a beam of light for selective photothermolysis comprising:

a pulsed tunable dye laser for amplifying light to generate a spatially noncoherent beam of light with an energy level of at least about one joule and a pulse duration greater than 10 microseconds; and

a pulse forming circuit for generating variable electric pulses for energizing the tunable dye laser, the pulse forming circuit providing variable length pulses through the range of at least about 10 microseconds to 500 microseconds.

8. The system of Claim 7 wherein the pulse forming circuit generates pulses of about one millisecond duration.

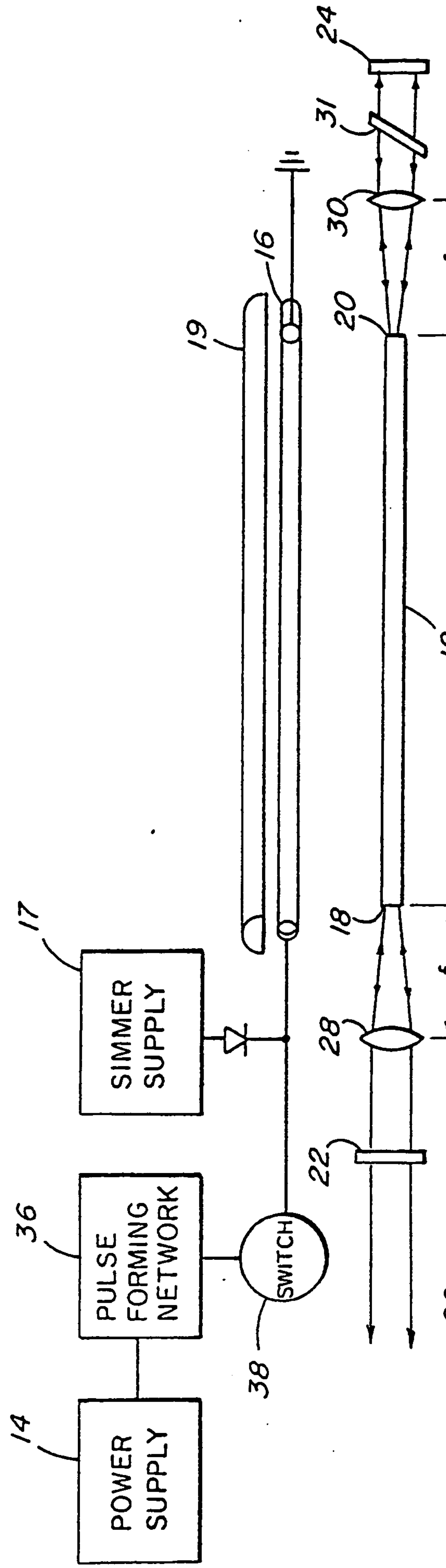
9. The system of Claim 7 wherein the pulsed tunable dye laser comprises:

a cell having a dye solution excitable to an energy level with net optical gain and apertures at opposite ends thereof, the Fresnel number of the cell being greater than one;

means for raising the medium to the excited energy level; and

an optical system at each end of the cell for imaging each aperture near to itself such that substantially all light within a wavelength band emanating from the aperture is returned to the cell through the aperture until the light passes through one of the optical systems as a beam.

10. The system of Claim 9 further comprising a tuning element to tune the laser across the gain curve of the dye solution.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SWITCH
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POWER SUPPLY

FIG. 1

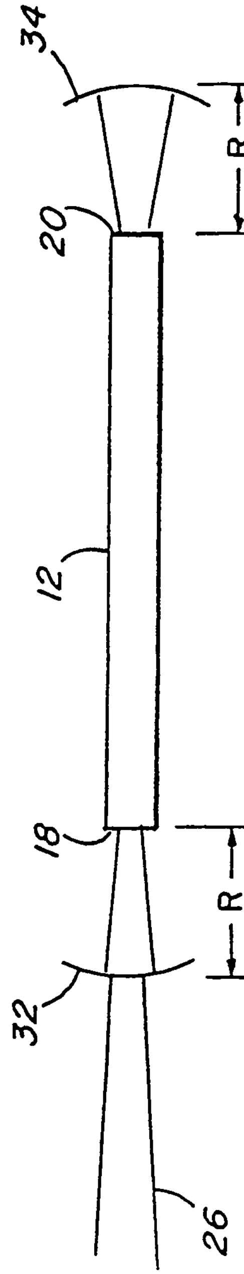
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FIG. 2

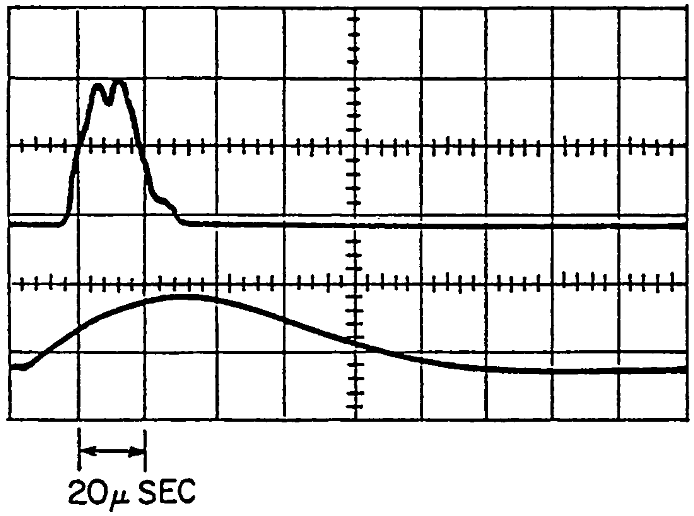

FIG. 3

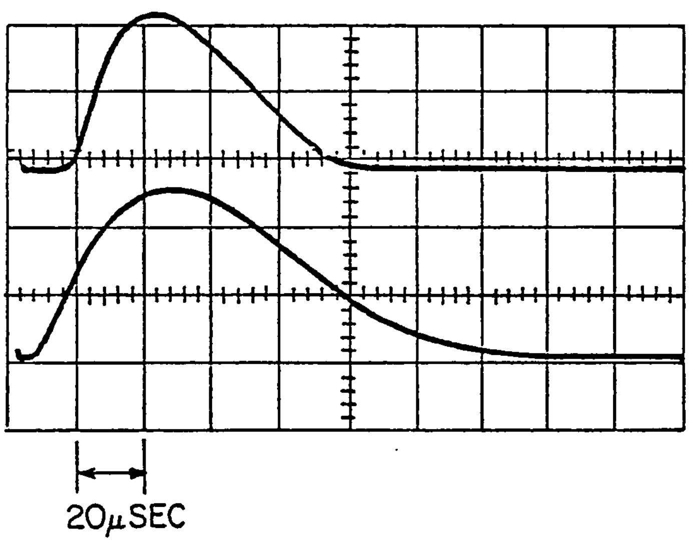

FIG. 4

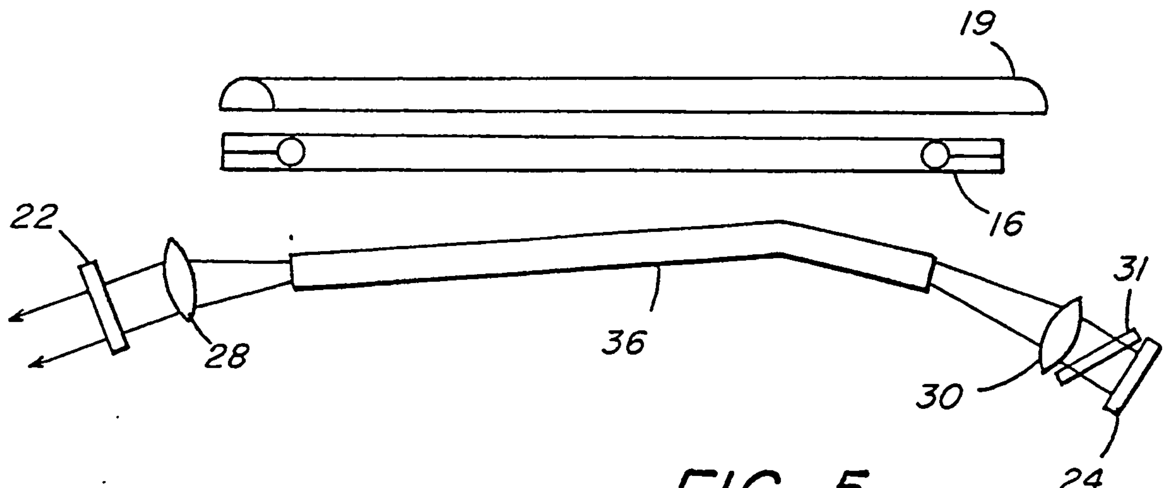

FIG. 5

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 85/02084

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[4]: H 01 S 3/08; 3/106; 3/692; A 61 B 17/36

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[4]	H 01 S 3/08; 3/106; 3/092; 3/20

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	IEEE Journal of Quantum Electronics, vol. QE-10, no. 10, October 1974 (New York, US) E.A. Maunders et al.: "Experiments on improved unstable mode profiles by aperture shaping", pages 821-822, see particularly figure 1 and page 821, right-hand column, paragraph 2 --	1
A	Optics and Spectroscopy, vol. 49, no. 5, November 1980 (New York, US) V.S. Smirnov: "Methods for reducing the divergence of lamp-excited rhodamine 6G solution lasers", pages 526-529, see particularly page 526, right-hand column - page 527, end of left-hand column --	1-3,5
A	Applied Optics, vol. 21, no. 15, August 1982 (New York, US) J. Jethwa et al.:"High-efficiency high-energy flashlamp-pumped dye laser", pages 2778-2779, see figures 2,5-6	4,7 ./.

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
5th February 1986	28 FEV. 1986
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	M. VAN MOL

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	Applied Optics, volume 18, no. 8, April 1979, New York, (US) T.K. Yee et al.:"Simmer-enhanced flashlamp-pumped dye laser", pages 1131-1132, see figure 1; page 1131, right-hand column, last two lines	4,7
A	IEEE Journal of Quantum Electronics, volume QE-10, no. 8, August 1974, New York, (US) G. Holtom et al.:"Design of a Birefringent filter for high-power dye lasers", pages 577-579, see page 578, right-hand column, lines 7-8	6,10
A	US, A, 3426293 (ELIAS SNITZER) 4 February 1969, see claim 1	1,6,10

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers .... because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers ...., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers.........., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

- see Annexe

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/210 (supplemental sheet (2)

Multiple inventions as follows:

- claims 1-3 : A multiple pass light amplifier comprising a cell with apertures and an optical system for imaging each aperture near to itself
- claims 4-6 : A method of amplifying light to develop a pulsed beam with a particular duration, energy and directional concentration
- claims 7-10 : A system for generating a beam of light for selective photothermolysis comprising a tunable dye laser with a particular excitation arrangement

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INTERNATIONAL APPLICATION NO. PCT/US 85/02084 (SA 11203)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 21/02/86

The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 3426293	04/02/69	None	